Asparagus

Yaguang Luo[1], Trevor Suslow[2] and Marita Cantwell[2]
[1]Produce Quality and Safety Laboratory, USDA, ARS
Henry A. Wallace Beltsville Agricultural Research Center, Beltsville, MD
[2]Department of Vegetable Crops, University of California, Davis, CA

Scientific Name and Introduction: Asparagus (*Asparagus officinalis* L.) is a perennial of the *Liliaceae* family. The edible portion of asparagus is a rapidly growing stem (shoot) with scale leaves that arise at nodes. There are two forms of asparagus in the marketplace, namely white (blanched) and green. White asparagus is widely used in Europe and Asia (Lipton, 1990); green asparagus is popular in the U.S. and is produced predominantly in California and Washington. Asparagus has a high metabolism after harvest and is among the most perishable crops.

Quality Characteristics and Criteria: High quality asparagus spears are dark green and firm with tightly closed and compact tips. Stems are straight, tender and glossy in appearance. Spears with green butts are preferred over the spears with white butts as the latter are associated with increased toughness. However, a small amount of white tissue at the butt will delay decay development under typical commercial distribution conditions (Lipton 1990; Suslow 2001).

Horticultural Maturity Indices: Asparagus spears are harvested as they emerge through the soil from the underground crowns. Typically, spears are cut when they reach 8 to 10 in, with spear tips still tightly closed. Tender, immature asparagus may be harvested for special market.

Grades, Sizes and Packaging: Harvested spears are prepared for market by grading, sizing, and bunching. Grades are based on freshness, length and diameter of the stalks, color of spears, tightness of the spear tips, and the extent of bruising. Spears of larger diameter are considered to be superior in quality with less fiber (Peirce, 1987). Sizing is based on spear diameter and each bunch is trimmed to a standard length of 7 to 10 in. The spears are tied in bunches weighing 1 lb (0.45 kg) to 2.5 lb (1.14 kg). After trimming the butt-end, the bunches are packed upright in trapezoidal shaped crates to minimize geotropic bending (curving away from gravity) in transit. The container should include a wet paper pad in contact with the butt end to maintain turgidity by replacing water lost by evaporation and used during elongation. Headspace is provided in the carton to allow for spear elongation without tip curvature or breakage.

Pre-cooling conditions: Asparagus is highly perishable and must be cooled immediately to 0 °C (32 °F) to 2 °C (35.6 °F). A 4-h delay in cooling resulted in an average 40% increase in shear force due to tissue toughening (Hernandez-Rivera et al., 1992). Asparagus is typically partially cooled during the washing, selection, and packing operation, and then hydro-cooled to near 0 °C (32 °F) after packing.

Optimum Storage Conditions: The recommended conditions for commercial storage of asparagus are 0 to 2 °C (32 to 35.6 °F) with 95 to 99% RH, yielding 14 to 21 days of storage-life. Maintaining a low storage temperature is critical to delay senescence, tissue toughening, and flavor loss (King et al., 1993). High RH is essential to prevent desiccation and to maintain freshness. Typically, asparagus is packed and shipped in containers with water-saturated pads to maintain high RH and prevent moisture loss. Excessive free water at elevated storage or shipping temperatures may lead to increased decay.

Controlled Atmosphere (CA) Considerations: Elevated CO_2 at 5 to 10% is beneficial in preventing decay and slowing toughening of the spears. Short exposure to higher CO_2 concentration is safe and

beneficial only if the temperature can be maintained at 0 °C (32 °F) to 1 °C (33.8 °F). The combination of intermediate O_2 (2 to 10% O_2) may or may not provide benefit compared to air enriched with CO_2 alone (Kleiber and Wills, 1992; Lill and Corrigan, 1996; Lipton 1990; Saltveit, 1997). At O_2 levels below 2%, off-odors and discoloration may develop. Signs of CO_2 injury are small to elongated pits, generally first observed just below tips. Severe CO_2 injury results in ribbiness. Asparagus tolerated a nitrogen atmosphere for 6 h at 2.5 °C (36.5 °F) or 20 °C (68 °F) without affecting sensory quality (Torres-Penaranda and Saltveit, 1994). High CO_2 (40 to 60%) can be applied at 5 °C (41 °F) for up to 4 days without affecting sensory quality, and may be used as an insect disinfestation treatment (Corrigan and Carpenter, 1993).

Retail Outlet Display Considerations: Asparagus is often displayed upright in trays with chilled water. It will also tolerate icing on retail displays. The preferred method to maintain freshness at retail display is refrigerated display with light misting.

Chilling Sensitivity: Asparagus is subject to chilling injury after about 10 days at 0 °C (32 °F). Symptoms include loss of sheen and glossiness and graying of tips. A limp, wilted appearance may be observed. Severe chilling injury may result in darkened spots or streaks near the tips.

Ethylene Production and Sensitivity: Ethylene production is low to intermediate, increases with time after harvest, and varies with where the spears are cut relative to soil surface (Lipton, 1990). For spears cut at the soil surface and held at 20 °C (68 °F) for 45 and 90 min, ethylene production changes from 2.1 and 3.1 μL kg^{-1} h^{-1} (Haard, et al., 1974). Exposure to ethylene accelerated the lignification (toughening) of asparagus spears (Hennion et al., 1992). Prompt cooling and maintaining optimal shipping temperatures minimizes ethylene-induced toughening.

Respiration Rates: Respiration rates depend on storage temperature, time after harvest and the spear portion on which determinations are made (Lipton, 1990). Freshly harvested asparagus is among the highest respiring fresh produce items. However, rates decline rapidly after harvest (King et al., 1990; Lipton, 1990). Respiration rates of the apical tips are much higher than those of the basal portions of the stems (Lill et al., 1990; Saltveit and Kasmire, 1985). Listed below are respiration rates of asparagus spears held at 20 °C for various times (Lipton 1957):

	Time after harvest (days)		
Temperature	**0.25**	**1.0**	**3.0**
		(mg CO_2 kg^{-1} h^{-1})	
0 ºC	80	60	40
5 ºC	145	105	65
10 ºC	305	215	120
15 ºC	325	235	160
20 ºC	500	270	185

To get mL kg^{-1} h^{-1}, divide the mg kg^{-1} h^{-1} rate by 2.0 at 0 °C (32 °F), 1.9 at 10 °C (50 °F), and 1.8 at 20 °C (68 °F). To calculate heat production, multiply mg kg^{-1} h^{-1} by 220 to get BTU per ton per day or by 61 to get kcal per metric ton per day.

Physiological Disorders:

Elongation and tip bending: Asparagus continues to grow and elongate after harvest if not cooled immediately and stored at low temperatures < 5 °C (41 °F). Contacting water at the butt will also promote spear growth and elongation. Tip bending occurs as the result of upward growth of the tips when the spears are horizontal. Held in an upright position, tip bending may still occur if the tips reach the top

of the package and are physically deflected. Postharvest heat treatment of asparagus spears in heated water at 45 to 50 °C (113 to 122 °F) for 2 to 5 min is beneficial for prevention of tip bending (Paull and Chen, 1999).

Spear toughening results from tissue lignification and fiber development, and progresses from butt to tip. This disorder develops at temperatures above 10 °C (50 °F), rapidly above 15 °C (59 °F), and is accelerated by the presence of ethylene.

Feathering denotes appearance of bracts of spear tips, which have opened due to outgrowth of the underlying buds. Tip feathering is a sign of senescence, often observed following extended storage at higher than optimal temperature or harvesting of over-mature spears.

Freezing injury occurs at temperatures below -0.5 °C (31.1 °F), and results in water-soaked appearance and tissue softening.

Postharvest Pathology: The most prominent postharvest disease on asparagus is bacteria soft rot, caused by *Pectobacterium carotovora*, or *Pseudomonas spp*. Decay may occur anywhere on the spears, in the form of "soft rot pits", most frequently on the tips or the butts (Snowdon 1992; Suslow, 2001). Spears with green butt are reported to be more susceptible to this decay than spears with white butts. Storing asparagus at low temperature < 5 °C (41 °F) is important to control this disease. In some production areas, the fungi such as *Fusarium*, *Penicillium*, and *Phytophthora* are associated with postharvest decay or spoilage of asparagus (Snowdon, 1992).

Quarantine Issues: Asparagus may be fumigated during international distribution and marketing if live common insects (hitchhikers) are found.

Suitability as Fresh-cut Product: The tender tender portion can be prepared as a food service product. There is limited minimal processing of asparagus, but consumer-oriented packing of tips is increasing.

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